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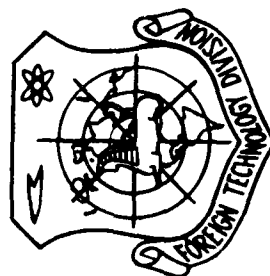
FOREIGN TECHNOLOGY DIVISION



THE EFFECT OF OXYGEN COMPOUNDS IN LUBRICATING OIL ON
INITIAL RUNNING-IN PROCESSES OF FRICTION COUPLES IN
INTERNAL COMBUSTION ENGINES

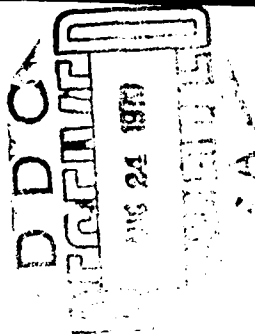
by

S. V. Ventsel', V. A. Lelyuk, et al.



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EDITED TRANSLATION

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By: S. V. Ventsel', V. A. Lelyuk, et al.

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THE EFFECT OF OXYGEN COMPOUNDS IN LUBRICATING OIL ON
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S. V. Ventsel', V. A. Lelyuk, Ye. I. Moiseyev,
and A. G. Tolmacheva

In recent years in works [1-2] a new mechanism of the interaction of oils, metals, and gas media under conditions of friction and wear was proposed and experimentally established. It was shown, in particular, that oxygen in the air is an active antiwear additive, and the role of the oil is to transport the oxygen to the friction surface.

In examining the question of the effect of oxygen on the friction and wear of metals under various regimes, the presence of two simultaneous processes must be considered: the oxidation of the oil with the formation in it of various oxygen compounds, and the oxidation of the surface (active) layers of the metal. These interlinked processes occur under conditions of a mutual connection. In its primary form this interrelation is expressed in the following two types of influence: 1) various oxidation products coming into contact with the friction surfaces exert not only a chemical influence but a physicochemical influence on them. Particularly noticeable are the internal and external wedge effect, instantaneous local thermal action on the contact surfaces of the microroughnesses, facilitation of the plastic flow, and other effects; 2) certain conditions on the friction surfaces,

namely: distortion of the crystal lattice, high contact temperatures and pressures, and structural transformations have a direct effect on the oxidation process of the oil, on the composition of oxidation products formed in the oil and, very significantly, on the structure of mechanical admixtures formed in the oil during its application.

We showed that in the process of friction and wear a so-called contact oxidation of the oil takes place, which is stimulated by conditions occurring during the instantaneous contacts of the microroughnesses [3]. As a result, products of the deep oxidative polymerization of carbon molecules of the oil are formed. These phenomenon were observed even under extremely low average temperatures of the friction surfaces. Later the significant role of insoluble mixtures formed in the oil and entering it during the functioning of the engines was shown. Wear products and particles of road dust in the used oil were covered by a coating of the surface-active products of the oxidative polymerization of carbon molecules in the oil.

The dimensions of the suspended particles, formed in the ageing of the oil, were large in comparison with the thickness of the boundary oil layers. Thus, the classic system of forming surface layers of polarly active oil components adsorbed on the metal must be fulfilled in the presence of relatively large particles of complex composition and structure in the gap, consisting of wear products, dust, and oxidation products of the oil.

As we indicated earlier, the antiwear action of the oil in internal combustion engines and in other machines and mechanisms is determined to a great degree by the relationship of organic and inorganic components of mechanical mixtures formed in the oil during its use. In the case of full covering of the abrasive center by a colloidal shield, consisting of different oxygen compounds formed by oxidation of the oil, the mechanical mixtures become the carriers of high antiwear and antifriction properties in the used oil [3].

The running-in process of the friction couples was studied by a number of researchers [4-6]. It was established, in particular, that the correct performance of this technological process guarantees a higher operational machine reliability. However, the mechanism of the effect of the running-in on higher wear resistance in practice remains as yet unclarified. This results from the fact that most researchers do not relate the running-in process with the effect of the oxygen transported by the oil to the friction surface, and when judging the results of the experiments base their conclusions on the original properties of the surfaces and of the lubricating oil without considering the significance of the oxidation processes occurring continually under friction and radically changing the properties of the friction couples and the oil. Consequently, in further developing concepts about phenomena which occur in the running-in of parts, complex methods of research must be used and the processes of the interrelation between the oil oxidation and the changes in the surface layer of metals during the running-in considered.

Laboratory experiments on a friction machine were conducted earlier and provided extremely significant results [7]. It was established that the friction coefficient of run-in surfaces and averaged temperatures are determined to a great extent not by the susceptibility of the surfaces to running-in (smoothing of the surfaces), as thought earlier, but by the state of the oil, the degree of its oxidation, and, in the final analysis, by the composition and quantity of mixtures formed in the oil during the running-in process or introduced into it earlier. Fresh oils, not containing oxidation products, showed the worst results. This paper presents the methods and results of factory experiments based on the above proposals.

In the experimental laboratory of a tractor assembly plant a series of tests on the running-in of cylinder-piston groups was conducted. Particular attention was given to research on the running-in process of cylinders and piston rings of the D-16 engine.

The cylinders of the D-16 engine were cast from gray alloyed iron. The internal diameter of the cylinder was 95 ± 0.06 mm. Based on this diameter the cylinders are divided into three size groups. For the experiment the middle group ($95^{+0.04}_{+0.02}$) was chosen. In order to increase its strength and wear resistance, the internal surface of the cylinder is subjected during its preparation to induction hardening to a depth of 1.5 mm and to tempering to an HRC hardness no less than 40. After hardening and tempering the internal surface of the cylinders is honed. The compression and oil-controlling rings are prepared of a special iron. The HRC hardness is 98-106. The exposed surface of the upper compression ring is covered with a chromium layer 0.1-0.17 mm thick. To avoid leaving a chromium deposit, the edges of the ring are rounded. For better running-in the working cylindrical surface of the rings is coated. The elasticity of the compression rings compressed to a gap at the joint of 0.4 ± 0.2 mm is equal to 1.75-2.5 kgf, and the elasticity of the lubricated rings 1.6-2.2 kgf. In setting the rings with an internal diameter of 95.00 mm, the gap at the joint is equal to 0.4 ± 0.2 mm.

The tests were conducted on a special stand with a hydraulic brake.

For breaking in the D-16 engine a special low-viscosity oil designed for breaking in diesel engines (VTU No. 587-56) was used as a standard. Viscosity $\nu_{50} = 24.1$ cSt ($\nu_{100} = 5.23$), acid number 0.07 mg. KOH per 1 g of oil, mechanical admixtures are absent.

The following oils were used as experimental: 1) DP-11 (fresh): GOST 5304, viscosity $\nu_{100} = 10.89$ cSt, acid number 0.006 mg KOH per 1 g of oil, mechanical admixtures are absent;

2) DP-11 (used): viscosity $\nu_{100} = 12.17$ cSt, acid number 0.65 mg KOH per 1 g of oil, mechanical admixtures: total - 1.46%, combustible - 1.2%, incombustible - 0.26%. The oil was poured from the crank case of tractor engine T-16, in which it had worked 50 h.

Preliminary laboratory experiments indicated that for coating engines any used oil of the type used in this engine was suitable, under the condition that it had previously worked no less than 50 h without changing. It is much more important that the ratio of organic components of the mechanical admixtures to the inorganic mixtures in the working oil be no less than 3. The last condition in most cases is self-fulfilling.

In the experiments the following running-in times were observed: 1 (only cold), 2, 3, 5, 6, 8, 5; 16; 26; 51 h.

In the transitions to each subsequent regime the piston rings and the cylinder sleeves of the engine were changed.

A comparison of the break-in results on fresh and used oils enabled establishing the characteristics of this process.

Figure 1 shows curves of the regularity of oxidation of fresh and used mineral oils as a function of break-in time. This graph illustrates the change in the acid number during break-in on fresh and used oils. As evident from these curves, the used oil has a greater stability in comparison with the fresh oil. The latter are very effectively oxidized during the course of only the first 2-6 h of the engine's work.

Figure 2 represents the change in the height of the micro-roughnesses (on the R_a scale) of the working surfaces of the cylinder cases during the breaking-in time for both fresh and used oils. Measurements of the cleanness of the surface of each sleeve were taken in five strips at distances 20, 37, 80, 140, 157 mm from its upper horizontal level. Here in each strip measurements were taken along four tracks (at every 90°). The final indicator of the cleanness of the working surface of the face of each cylinder was determined as the arithmetic mean value of 20 completed measurements. Profilograms of the rings were taken by a special device. From each piston ring about six profilograms were taken (at each 60°). Graphs of the curves of the

change in the cleanness of the ring surfaces repeat the regularities shown in Fig. 2 for the sleeves. The cleanness of the working surfaces of the cylinders and piston rings was determined on a "Kalibr-VEI" profilometer-profilograph.

Figure 3 shows curves describing the wear of piston rings (by weight). Examination of Figs. 2 and 3 shows that when using the used oil in the initial breaking-in stage, wear was higher than with fresh oil. However, the wear then becomes stabilized, while with fresh oils the wear has a tendency to increase. In conformity with this, the best leveling of the surface is obtained with used oils. Subsequently the lowest roughness is established (see Fig. 2).

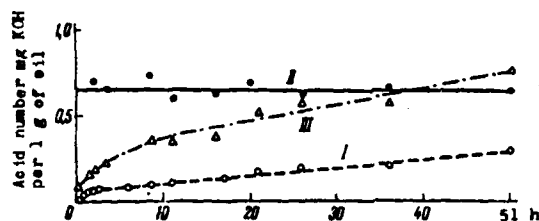


Fig. 1. Diagram of the change in acid number in running-in time of the engine.
I - For fresh oil DP-11; II - for used oil DP-11; III - with a special fresh break-in oil.

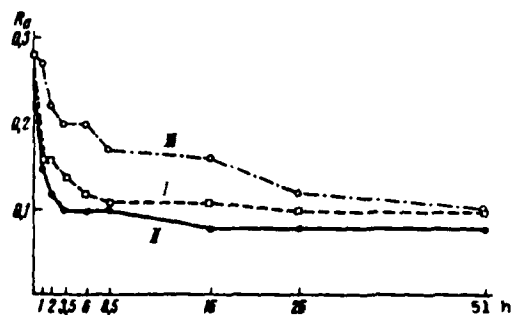


Fig. 2. Diagram showing change in roughness of working surfaces of the sleeves during running-in time.
Designations the same as in Fig. 1.

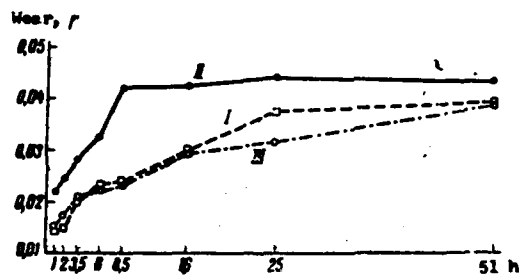


Fig. 3. Diagram of the change in weight wear of piston rings during break-in time.
Designations the same as in Fig. 1.

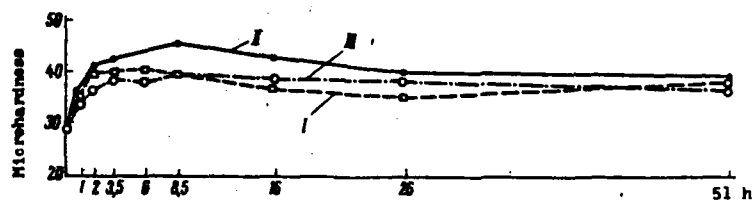


Fig. 4. Diagram of the change in microhardness of working surfaces of piston rings during break-in time.
Designations the same as in Fig. 1.

	Two-hour running-in					50-hour running-in			
	N_{ef}	n	η_m	P_T , kgf/cm ²	N_T , hp	N_{ef} , hp	η_m	P_T , kgf/cm ²	N_T , hp
Special break-in oil	15.9	1600	0.605	2.22	6.65	16.25	0.740	1.88	5.74
Fresh diesel oil Em-11	16.25		0.703	2.13	6.48	16.8	0.760	1.75	5.36
Used diesel oil Em-11	17.25		0.750	1.95	5.9	17.25	0.765	1.70	4.95

Figure 4 shows the curves of the change in the microhardness of the ring surface. The used oil gave the highest microhardnesses for rings after break-in.

Figures 5 and 6 show regulating characteristics of engines recorded after two-hour (Fig. 5) and 50-hour break-in (Fig. 6).

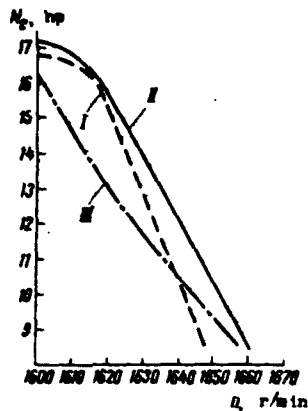


Fig. 5. Regulating characteristics of engine D-16 after two-hour bench break-in. Designations the same as in Fig. 1.

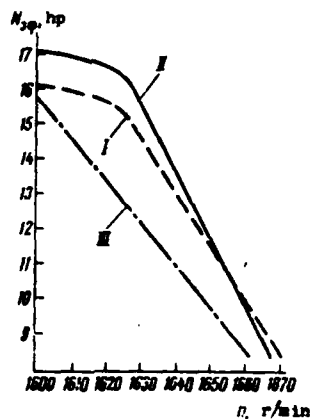


Fig. 6. Regulating characteristics of engine D-16 after 50-hour bench break-in. Designations the same as in Fig. 1.

Usually the break-in time of engine D-16 was determined by the time during which the engine could be run-in to a point where its power attains 16 ± 0.5 hp. Further tests under factory conditions showed that break-in of engine D-16 on used oil is decreased significantly in time in comparison with break-in on fresh oils, including special break-in oil. As a result of the higher quality of obtained surfaces and of piston antifriction properties of the used oils in comparison with the fresh, higher power and less friction loss in the engines broken in on used oil were obtained. Characteristic also was the reduction of the time required for break-in in this case.

The results obtained confirm the greater value of oxidation products formed in the oil and affecting the break-in processes of the surfaces. Due to more favorable thermal conditions of the contact of microroughnesses, the forces of the plastic flow of the microscopic projections, leveling of the surfaces, and other effects, the used oil provides a better qualitative preparation of the surfaces for receiving industrial loads. It should be mentioned that the special break-in oil with the additive gave, by all parameters, the worst results. The higher cleanness of surfaces obtained during break-in on used oil assures, for later use, the following: 1) less wear, since the actual contact area is increased and the strength of the oil film raised; 2) a higher fatigue resistance of parts, since the probability of concentrations of stresses in irregularity cavities is decreased; 3) an increase in corrosion resistance. The results of the microhardness measurements indicated that in the wear process a hardening of the friction surface of rings and sleeves occurs due to increased microhardness. For the surface of the parts, which were broken in on used oil, a degree of hardening greater than for fresh oils provides greater wear resistance for rings under operational conditions. Thus, the following conclusions can be drawn.

1. The break-in of engines evaluated according to wear, microroughness, and microhardness is accelerated by the use of used oil as compared to fresh and special break-in oils with additives.
2. The use of used oils provides the best preparation of friction surfaces for receiving operational loads.
3. As a result of break-in on used oils, engine power and mechanical efficiency are increased, while friction loss is decreased.
4. The great positive effect of atmospheric oxygen was confirmed as a unique active additive which accelerates the break-in process and improves the condition of surfaces, making them more receptive to operational loads.

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13. ABSTRACT The effect of the oxygen compounds formed in used oils on wear and on engine performance resulting from the running-in process was studied. Cylinders and piston rings of the diesel engine D-16 were tested in the laboratory of a tractor factory. The cylinders are cast from gray alloyed iron and annealed and hardened to provide a treated surface layer of 1.5 mm depth and not less than hardness 40 HRS; rings, made from a special cast iron, have 98-106 hardness HRS. Running-in was studied with a special additive oil compounded for running-in, VTU No. 587-56, and with fresh and used diesel oil DP-11, GOST 5304; the used oil, used 50 hrs in the crankcase of tractor T-16, contained 1.46 percent mechanical impuri- ties and had acidity corresponding to 0.65 mg KOH per 1 g oil. The authors had shown in published studies the presence of oxidation products in such oils, formed by oxidative polymerization of hydro- carbons. Wear, microhardness, and microroughness of friction sur- faces were determined as indicators of the running-in process. This process was accelerated with the used oil as compared with the fresh oil or with special lubricant VTU. The used oil produced the best friction surface for loads occurring under field conditions. Orig. art. has: 6 figures and 1 table. [AT8021010]			

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Metal Friction Lubrication Oxygen Oxygen Compound Oxygen Impurity Diesel Engine Tractor Lubricating Oil Hardness Wear Test Surface Roughness						

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